ORIGINAL ARTICLE

Endoscopic Radial Artery Harvest for Coronary Artery Bypass Surgery

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Background/Purpose: Coronary artery bypass grafting (CABG) provides better long-term patency than percutaneous intervention in patients with significant coronary artery disease. The radial artery is the second most common arterial conduit used for CABG in Western countries. However, radial artery harvesting necessitates a large surgical wound and has gained few patients' acceptance in subtropical areas. This study investigated the use of the minimally invasive approach of endoscopic radial artery harvest for CABG, and the surgical results at the harvest site.

Methods: An endoscopic harvest program for radial arteries was implemented in this hospital in September 2003. During the first 12 months of the program until September 2004, 122 patients underwent the procedure. Preoperative evaluation included Allen's test and the modified palmar arch perfusion test. The age of patients ranged from 32 to 88 years old. Patients were excluded from participation if they had undergone recent transradial catheterization, had end-stage renal disease or documented peripheral artery occlusive disease. The VasoView® system was utilized for the procedure. Details of the surgical techniques used were recorded and analyzed.

Results: Using the endoscopic technique, 122 radial arteries were harvested successfully. The mean resting length of the harvested radial artery was 15.7 cm. No obvious arterial injury was visually confirmed. All radial arteries were used for CABG, except for two which were noted to have atherosclerotic plaques causing stenoses. Forty-seven patients presented with mild numbness over the dorsum of the thumb base, which improved significantly during the 3-month follow-up. No arterial insufficiency in the forearms or hands was noted.

Conclusion: Endoscopic harvest of the radial artery is technically demanding, but excellent results can be achieved. The endoscopic approach can provide suitable conduits in a less invasive way than the open harvest technique. [*J Formos Med Assoc* 2006;105(5):384–389]

Key Words: coronary artery bypass, endoscopic harvest, radial artery

Coronary artery bypass surgery has been established as a successful treatment for coronary artery disease for more than 30 years. Although the number of percutaneous interventions has exceeded that of coronary artery bypass grafting (CABG) in the last two decades, CABG still has the advantages of durability, symptom relief, less re-intervention and survival benefit.[1–4] Although the saphenous vein is still the most commonly used conduit for CABG, the left internal mammary artery (LIMA) is the graft of choice as it provides the best long-term patency.[5] Other arterial conduits including the right internal mammary artery (RIMA), radial artery, and gastroepiploic artery were also reported to have better 5- to 10-year-patencies than vein grafts.[5–7] Use of the radial

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artery for CABG was first introduced in the mid-1970s. Although the initial results were not good enough, unexpectedly good long-term patency in some patients aroused an interest in re-investigation.[8,9] From then on, more and more evidence supported the use of the radial artery for CABG.[10–15] Use of the radial artery for the second arterial conduit was reported to result in a lower incidence of sternal wound infection and decreased transfusion requirements than with the RIMA.[16] Caputo et al reported that radial artery graft had better protective effect than RIMA graft, assuming that the LIMA was used for the first arterial graft, in both early and midterm outcomes of myocardial revascularization, including perioperative myocardial infarction, atrial fibrillation, postoperative transfusion, intensive care unit stay, and survival free from any cardiac-related event or death.[17]

Harvest of the radial artery has usually been accomplished by open techniques, which result in a marked forearm scar.[18] Such techniques are poorly accepted by patients in tropical or subtropical areas due to cosmetic reasons. Current technological advancements allow surgeons to perform radial artery harvesting endoscopically.[19,20] This study analyzed the short-term results of endoscopic radial artery harvest in the first 122 patients who received this procedure as part of a program at our hospital.

Methods

An endoscopic vessel harvest (EVH) program for radial arteries was started at Far-Eastern Memorial Hospital in September 2003. Patients with an indication to undergo CABG with more than LIMA to left anterior descending coronary artery anastomosis were enrolled to assess the feasibility of radial artery harvest. Patients with end-stage renal disease or documented peripheral artery occlusive disease were excluded. Patients who had recently undergone invasive procedures involving the left radial artery such as indwelling arterial line or transradial cardiac catheterization were also excluded. The non-dominant hand was always chosen for the procedure. Allen's test was performed preoperatively to assess collateral circulation. The palmar arch perfusion test using plethysmography was then performed for the decision confirmation when the use of a radial artery graft was proposed. In the operating theater, a modified Allen's test using pulse oximetry for the saturation waveform of the left thumb was performed again. These maneuvers aimed to avoid putting limb circulation in jeopardy. From September 2003 to September 2004, 340 patients underwent CABG in our hospital. Among them, 122 patients underwent EVH for the radial artery. The clinical and demographic data of these patients are shown in Table 1.

Surgical techniques

No other procedures were performed on the left upper extremity prior to the surgical interventions. Sponge rolls were applied at the mid-arm level layer by layer as the cushion for the tourniquet. The entire hand, forearm and elbow were painted with alcohol beta-iodine and draped. The wrist was hyperextended with a towel roll underneath.

A 2.5- to 3-cm longitudinal incision was made about 2 cm above the skin crease of the wrist, lateral to the palmaris longus tendon and slightly medial to the radial pulse. Electrocautery was usually avoided to prevent inadvertent injury to the superficial radial nerve. After exposure of the radial artery along with concomitant veins, extensive undermining dissection was carried out proximally to allow the subsequent insertion of a balloon trocar. The limb was then exsanguinated with Esmark bandage and the tourniquet was filled with a pressure of 200 mmHg.

The VasoView® system (Guidant Corp, Santa Clara, CA, USA) was used for EVH. After insertion of the balloon trocar, 15 cmH_2O pressure of carbon dioxide was applied to fill up the perivascular sheath and to facilitate further dissection. Blunt dissection was performed along the entire vascular bundle to the elbow using a specially designed cone. Then, another instrument containing a C-ring retractor and electrocautery scissors was used

Table 1. Clinical characteristics of patients receiving endoscopic vessel harvest (EVH) of the radial artery for coronary artery bypass grafting

Mean age, yr (range)	62 (32–88)
Male/Female, *n*	106/16
Mean LVEF, % (range)	57 (28–85)
Coronary lesions, *n*	
3-vessel disease	103
2-vessel disease	19
Procedure, *n*	
OPCAB	114
ONCAB	8
LIMA as donor, *n*	
Y graft	113
End to end extension	7
Distal anastomosis/patient	3.18
RA-LAD	22
RA-diagonal	78
RA-obtuse marginal	102
RA-RCA branches	69
LIMA-LAD	98
SVG to coronary artery	12
RIMA-RCA	1
Radial artery EVH	
Mean tourniquet time, min (range)	45 (27–69)
Mean resting length, cm (range)	15.7 (14.5–21)

LVEF = left ventricular ejection fraction; OPCAB = off-pump coronary artery bypass; ONCAB = on-pump coronary artery bypass; LIMA = left internal mammary artery; RA = radial artery; LAD = left anterior descending coronary artery; RCA = right coronary artery; SVG = saphenous vein graft; RIMA = right internal mammary artery.

to divide the remaining connections between the vascular bundle and the surrounding tissue. A 0.5-cm stab wound directly over the proximal radial artery about 2 cm below the elbow skin crease was made. A mosquito clamp was inserted via the stab wound to clamp the radial artery. The radial artery was then divided by the endoscopic scissors and the distal part was pulled out with the C-ring retractor. The proximal end of the radial artery was suture-ligated. The remaining dissection was carried out by conventional open techniques to free the radial artery beyond the limit of the surgical wound.

The isolated radial artery was flushed and soaked with homemade cocktail solution containing 5 mg nicardipine, 0.2 mg lidocaine, 50 mg nitroprusside, 5000 IU heparin and 100 mL saline. Following the completion of wound repair, the forearm was wrapped with an elastic bandage and the tourniquet was then deflated. All radial arteries used were constructed as Y or T graft from the LIMA trunk. All the radial artery branches were clipped after the proximal anastomosis was constructed. The targets of revascularization consisted of all coronary artery branches of three-vessel territories.

The circulation of the left hand was continuously monitored by pulse oximetry. The elastic bandage was removed on postoperative day 3. A questionnaire concerning hand function was answered by every patient on postoperative day 7 and 3 months later.

Results

The hospital mortality was 1.6%. The average number of grafts per patient was 3.18. Technical success for EVH was achieved in every patient. The duration of tourniquet inflation ranged from 27 to 69 minutes (mean, 45 minutes). The resting length of the radial artery ranged from 14.5 to 21 cm (mean, 15.7 cm). Two radial arteries were discarded due to obvious plaques. One patient sustained an inadvertent injury to the proximal ulnar artery which required open repair. No other patient suffered ischemic injury of the hand. Nine patients had inadequate length of radial artery for CABG and needed graft extension with saphenous veins (8 patients) and RIMA (1 patient). The other patients all received total arterial coronary artery bypass surgery. Forearm ecchymosis was common after EVH of the radial artery. One patient had excessive wound bleeding, which demanded re-exploration via the same wound. One patient had wrist wound infection, which required intravenous antibiotic treatment for 1 week.

Hand function after EVH of the radial artery was assessed using a questionnaire. Follow-up

was complete in 100% of patients (Table 2). Grasping ability was defined as fine and smooth performance of grasping without any difficulty. Weakness was defined as the occurrence of fatigue after 30 forceful squeezes of a rubber ball. On the sensory part of the questionnaire, 49 out of 122 patients complained of wound pain, 47 patients complained of local numbness confined mainly to the dorsum of the thumb base, and 18 patients had a tingling sensation on postoperative day 7. Regarding motor function, the right hands of patients served as the control group. Eleven patients complained of a defect in their grasping ability, and four patients complained of weakness.

At 3 months after the operation, only mild sensory deficits were noted. Two patients developed keloids and presented with pain and tingling sensation. One-fifth of patients still had mild numbness, although the extent and severity were greatly improved. Only one patient suffered from marked numbness and tingling sensation. Neuroma was suspected and he was referred to our rehabilitation department for transcutaneous electrical stimulation therapy. All patients were satisfied with the appearance of their surgical wounds.

Discussion

The radial artery is the second most common arterial conduit used for CABG after the internal mammary artery. Conventional harvesting techniques require a long or interrupted surgical wound over the forearm from the wrist to the elbow. Although few complications are encountered, the surgical scar remains an issue both physically and mentally. Injury to the lateral branch of the antebrachial cutaneous nerve or superficial radial nerve is an often encountered problem. In this study, the EVH technique used for the radial artery was adapted from the technique used to harvest the saphenous vein. Both techniques use the same instruments. EVH of the radial artery is even easier to perform because the tourniquet technique prevents troublesome oozing from the dissecting tunnel and potential air embolism from carbon dioxide inflation.[21] Hemostasis is extremely important, especially for patients who are on antiplatelet agents or anticoagulants. Fast and abrupt use of bipolar electrocautery scissors might cause significant bleeding once the tourniquet is deflated. The elastic bandage significantly aids hemostasis, but too tight wrapping might cause poor blood supply and patient discomfort.

Gentle handling of the conduits should always be emphasized. The radial artery is notorious for vasospasm, especially during the manipulation and early postoperative period. In addition, invasive procedures in the conduit before the operation should always be avoided. In our institution, more than 80% of cardiac catheterizations are performed via the radial artery. Therefore, patients who have undergone invasive manipulation of the radial artery within 1 month are excluded from candidacy for EVH.[22] The radial artery procurement collects the vascular bundle as a whole. The concomitant veins help to prevent friction injury over the radial artery proper. During blunt dissection, the pressure of carbon dioxide was used to separate the tissue planes. The blunt cone dissector was used to create a parallel tunnel surrounding the vascular bundle. Care should always be taken to avoid direct contact of the cone tip with the radial artery. The major weakness of this procedure is the insertion of the balloon trocar. The balloon trocar should be air-tight. Some contact and pressure right over the radial artery is inevitable in that particular segment. After having noted this pitfall from our early experience with EVH of the saphenous vein, we just inserted the balloon trocar snugly and never inflated the balloon due to risk of causing further pressure-related injury to the radial artery. Once the procurement was com-

Table 2. Hand function assessment

	Postoperative day 7	After 3 months
Grasping deficit, *n*	11	0
Weakness, *n*	4	0
Numbness, *n*	47	25
Pain, *n*	49	3
Tingling sensation, *n*	18	2

pleted, spasm of the radial artery was frequently encountered. This was mainly due to the initial forceful exsanguination by Esmark bandage and tourniquet. Forceful mechanical dilatation should always be prohibited. Gentle flushing and soaking with vasodilatation agents are strongly recommended, using cocktail vasodilatation solution containing calcium channel blocker, nitroprusside and xylocaine.[23,24] In our recent series, heparinized whole blood was used to replace saline.[25] As soon as the proximal anastomosis of the radial artery was completed, the radial artery was dilated by the native blood pressure. All bleeding branches were then clipped. The prepared conduit was, thereafter, ready for distal anastomosis.

Deficits of motor function were rarely encountered during postoperative follow-up. Meticulous preoperative evaluation to ensure collateral circulation is key to preventing this potential disaster. Previous studies showed limited impairment of sensation.[26] However, sensory deficits were common in this series. Nearly 40% of patients developed numbness in the territory of the superficial radial nerve in the early postoperative period. Although all of these patients experienced significant improvement after 3 months, one-fifth of patients had residual numbness. The vicinity of the superficial radial nerve and radial artery might explain the complications. Most of those impairments occurred in the early experience of our radial artery EVH program. During this period, we shifted the surgical incision site more medially, instead of directly on the top of the radial pulse. We also tried to create a flap to protect the superficial radial nerve. Less use of electrocautery at the beginning and end of the procedure further reduced the incidence of numbness. Complete transection of the superficial radial nerve did not occur in this series. In comparison with conventional open techniques, the nerve injury seemed to be relatively mild. In our experience, more than 6 months might be required to allow for nerve regeneration and complete freedom from symptoms.

In conclusion, EVH of the radial artery is a technically feasible method that provides a good arterial conduit for coronary revascularization, excellent cosmesis, and rapid return to normal activity. Providing a better conduit for coronary revascularization using this minimally invasive technique should always be considered. However, further evaluation of the long-term patency of this conduit is mandatory. We suggest that every cardiovascular surgeon begin by learning EVH of the saphenous vein to accumulate experience in atraumatic dissection and endoscopic handling. After completing this learning curve, EVH of the radial artery would be the next logical step.

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